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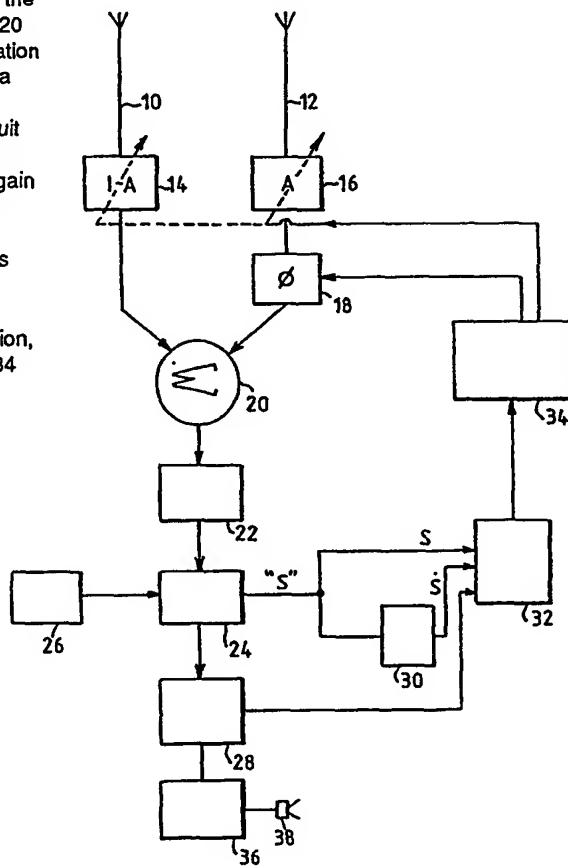
(56) Documents cited  
GB 2199468 A GB 2063623 A GB 1506276 A  
GB 1129177 A WO 89/04092 A1 US 4512034 A

(58) Field of search  
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(54) Multiple antenna broadcast reception system for a motor vehicle

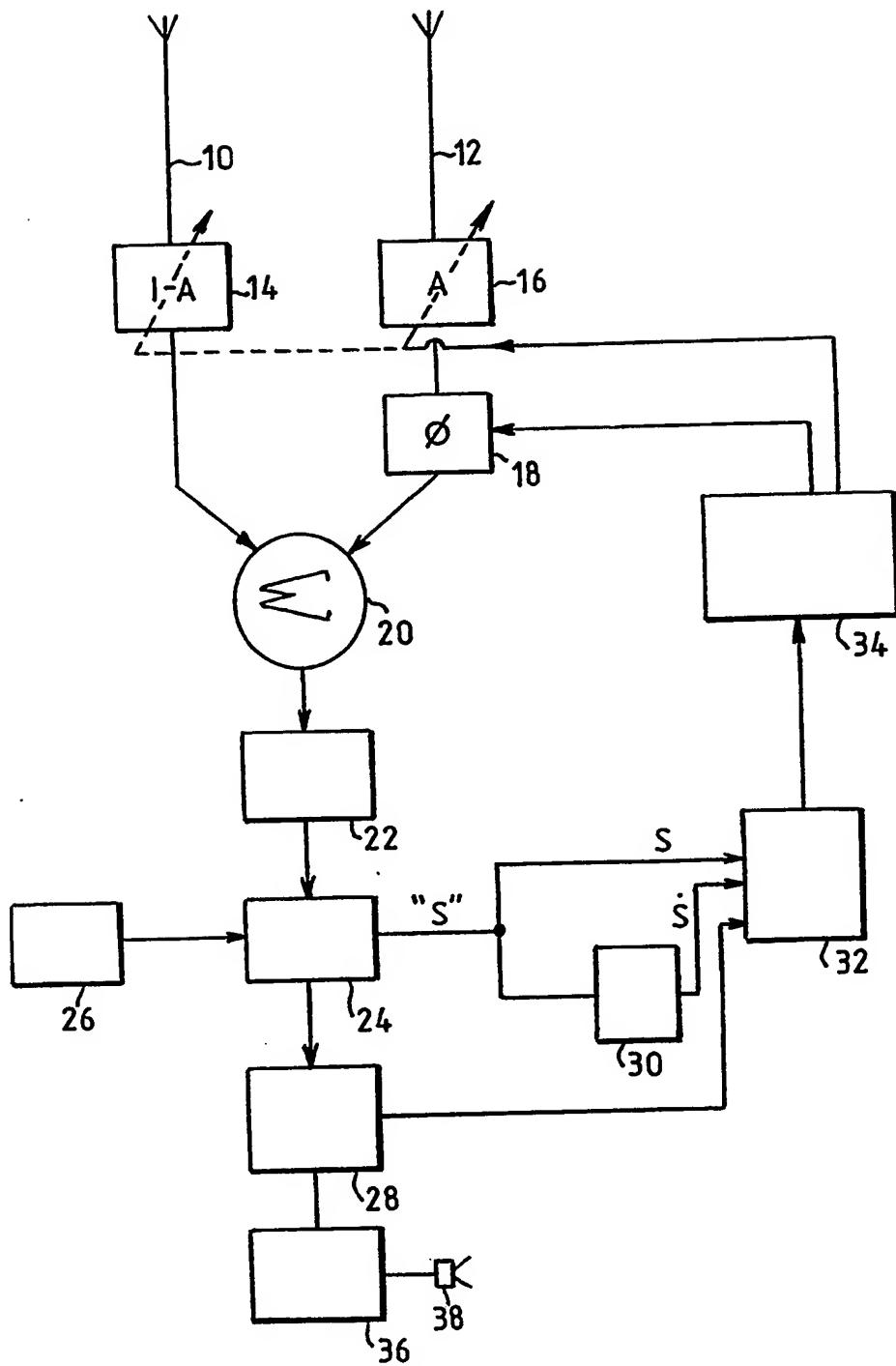
(57) The receiver comprises broad-band adjustable amplifiers 14, 16 for varying the relative radio signal amplitudes from individual antennae 10, 12, a phase shifter 18 for varying the relative phase of the amplified radio signals and a circuit 20 for summing the signals from the antennae after amplification and phase shifting and supplying the combined signal to a single tuner 22, 24, 26, 28, 36, 38.

The quality of the received signal is sensed in a circuit 32 and used to provide a control variable to a feedback control circuit 34 which adjusts the values of the relative gain and phase shift to maximise perceived signal quality, the control circuit effecting perturbation of the amplitude and phase settings so that they continually dither about values which optimise the output signal quality. Circuit 32 may receive inputs indicative of the signal strength of an FM signal, the level of any super imposed amplitude modulation, and an input indicative of distortion. Circuits 30, 32 and 34 may be implemented as a micro-computer.



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MULTIPLE ANTENNA BROADCAST RECEPTION SYSTEM  
FOR A MOTOR VEHICLE

The invention relates to a multiple antenna broadcast  
5 reception system for a motor vehicle.

Background of the invention

It is well known that the overall directional sensitivity  
10 of an antenna array can be modified by varying the  
relative amplitudes and phases of the signals from the  
individual elements of the array before they are combined.  
This principle is used, inter alia, to effect direction  
finding and beam steering in radar arrays. Of course,  
15 such arrays are designed to operate in the microwave  
region of the spectrum and have little if any relevance to  
broadcast receivers in motor vehicles.

It has more recently been proposed to use an adaptive  
20 antenna system in a vehicle broadcast receiver. In these  
systems, two or more antennae are used and the signal from  
each is separately amplified in a respective tuned r.f.  
amplifier of a multi-channel receiver. The radio signals  
from the individual channels are phase shifted in relation  
25 to one another and later combined to produce the composite  
signal which is then demodulated in the normal way to  
produce an audible sound. The signal quality in the  
individual channels of the receiver is monitored, as is  
the overall reception quality, and the control parameters  
30 of the individual channels, namely phase and gain, are  
varied in order to maximise reception quality by a  
suitable closed feedback loop.

The above receiver provides acceptable reception quality  
35 and adapts automatically to changes in the transmission  
path which would normally tend to degrade reception  
quality. However, it suffers from the disadvantage of  
being costly on account of the duplication of the so-

called front end circuits of the receiver, since the signal from each antenna is separately processed before the signals from the different channels are combined.

5    Object of the invention

The present invention seeks to provide a broadcast receiver which benefits from an adaptive antenna system but does not require multiple radio frequency channels to  
10 process the signals from the individual antennae separately.

Summary of the invention

15 According to the present invention, a broadcast receiver for a motor vehicle comprises :

two or more antennae,

20 broad band adjustable amplifying means for varying the relative radio signal amplitudes from the individual antennae,

25 phase shifting means for varying the relative phase of the radio signals from the individual antennae,

means for summing the signals from the antennae after amplification and phase shifting and supplying the combined signal to a single tuner,

30 means for generating a control signal indicative of the quality of the output signal of the tuner, and

35 a control circuit for adjusting the relative phase and amplitude of the signals from the individual antennae prior to combination in order to improve signal quality,

wherein the control circuit is arranged to effect perturbation of the amplitude and phase settings whereby the phase and amplification settings will continually dither about values which optimise the  
5 output signal quality.

The signal quality may conveniently be indicated by the signal strength of the output of the tuner. However, signal strength alone will not indicate poor reception  
10 resulting from multi-path conditions, particularly long delay multi-path. Such conditions result in amplitude modulation of the FM signal and distortion to the demodulated signal. It is therefore desirable to vary the relative phases and amplitudes of the signals from the  
15 antennae in order also to avoid or minimise such amplitude modulation and signal distortion.

Because several criteria are involved in the determination of the signal quality, it is desirable to use a micro-  
20 processor to generate the control signal for varying the amplitudes and phases of the signals from the individual antennae by means of a suitable perturbation algorithm.

The invention will now be described further, by way of  
25 example, with reference to the accompanying drawing which is a block circuit diagram of a broadcast receiver of the invention.

A radio broadcast signal is received by means of two  
30 antennae 10 and 12 mounted in spaced relation on a motor vehicle body. The respective received signals are amplified by broad band (not-tuned) amplifiers 14 and 16 and combined with one another in a summation circuit 20 after the signal from the amplifier 16 has been phase  
35 shifted by a circuit 18. The gains of the amplifiers 14 and 16 and the phase shift introduced by the circuit 18 are all under the control of a micro-processor 34, as further explained below.

Following combination of the signals from the two antennae, the combined signal is processed using conventional circuitry as found in a tuner connected to a single antenna. In the illustrated embodiment, the various 5 stages of a conventional super-heterodyne receiver are shown, namely an RF stage or stages 22, a local oscillator 26, an IF (intermediate frequency) stage 24, and an FM demodulator 28. The demodulated output is supplied to an AF (audio frequency) amplifier 36 which in turns drives 10 the loudspeaker 38.

An output representative of signal strength is supplied by the IF stage 24 directly to a quality determination circuit 32. The latter circuit also receives a signal 15 from a differentiating circuit 30 representing the time derivative of the signal strength, i.e. the level of any super imposed modulation. A further input signal for the circuit 32, representative of distortion, is taken from the demodulator 28. The micro-processor 34 is connected 20 to the circuit and continuously varies the gains of the amplifiers 14 and 16 and the phase shift of the circuit 18 to maximise the perceived quality of the audio signal.

In practice, the blocks 30, 32 and 34 are all conveniently 25 implemented as a single micro-computer with A/D converters for the signals from the IF stage 24 and the demodulator 28. The circuit 32 is implemented as a program or control algorithm which develops an output value related to perceived signal quality. The block 34 will at all times 30 make a change to the existing values of gain and phase and monitor the resulting change in perceived signal quality and changes will always be made in the sense to maximise perceived quality.

35 One suitable algorithm involves varying the amplitudes and phase separately in different control cycles but other algorithms may be employed.

It is preferred to gang the two amplifiers 14 and 16 such that the gain of one is reduced in proportion to the increase in the gain of the other, hence decreasing the complexity and reaction time of the control algorithm.

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An important advantage of the receiver of the preferred embodiment of the invention is that it does not maximise signal strength alone but takes into account signal quality as represented by super-imposed amplitude

10 modulation and signal distortion and in this way attempts to mitigate problems caused by multi-path signal propagation.

The combination of the antenna signals results in the

15 receiver having maximum sensitivity in some directions and nulls in others. The effect of varying the relative amplitudes and phases is to modify these patterns and the algorithm used in the preferred embodiment of the invention not only seeks to maximise the sensitivity in

20 the direction of the desired signal but to attenuate interfering signals from other directions.

CLAIMS

1. A broadcast receiver for a motor vehicle comprising:

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two or more antennae,

broad band adjustable amplifying means for varying the relative radio signal amplitudes from the  
10 individual antennae,

phase shifting means for varying the relative phase of the radio signals from the individual antennae,

15

means for summing the signals from the antennae after amplification and phase shifting and supplying the combined signal to a single tuner,

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means for generating a control signal indicative of the quality of the output signal of the tuner, and

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a control circuit for adjusting the relative phase and amplitude of the signals from the individual antennae prior to combination in order to improve signal quality,

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wherein the control circuit is arranged to effect perturbation of the amplitude and phase settings whereby the phase and amplification settings will continually dither about values which optimise the output signal quality.

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2. A receiver as claimed in claim 1, wherein the means for generating a control signal indicative of the quality of the output signal of the tuner, comprises means for measuring the strength of the received FM signal.

3. A receiver as claimed in claim 2, wherein the means for generating a control signal indicative of the quality of the output signal of the tuner further comprises means for sensing amplitude modulation of the received FM signal.
4. A receiver as claimed in claim 2 or 3, wherein the means for generating a control signal indicative of the quality of the output signal of the tuner further comprises means for sensing distortion of the signal after demodulation.
5. A receiver as claimed in any preceding claim, wherein the control circuit for adjusting the relative phase and amplitude of the signals from the individual antennae prior to combination in order to improve signal quality comprises a programmed micro-computer.
6. A broadcast receiver for a motor vehicle constructed, arranged and adapted to operate substantially as herein described with reference to and as illustrated in the accompanying drawing.

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Patents Act 1977  
Examiner's report to the Comptroller under  
Section 17 (The Search Report)

Application number

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Relevant Technical fields		Search Examiner
(i) UK CI (Edition K )	H4L LDDRCP, LDDRGW, LDDRCX,	M J BILLING
(ii) Int CI (Edition 5 )	HO4B 7/00, 7/02, 7/04, 7/08	
Databases (see over)		Date of Search
(i) UK Patent Office		18 APRIL 1991
(ii)		

Documents considered relevant following a search in respect of claims

1 TO 5

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB 2199468 A (A.T. & T.) - eg see Figure 1	1,2 at least
X	GB 2063623 A (NIPON ELECTRIC) - eg see Figure 3	1,2 at least
X	GB 1506276 A (MARCONI) - eg see Figure 2	1,2 at least
Y	GB 1129177 A (MINISTER OF TECHNOLOGY) eg see Figure 1	1 at least
X	WO 89/04092 A1 (HIRSCHMANN) - eg see Figure 1, Abstract	1,2,3 at least
X	US 4512034 A (A.T. & T.) - eg see Figure 1	1,2,5 at least

SF2(p)

Category	Identity of document and relevant passages	Relevant to claim(s)

#### Categories of documents

X: Document indicating lack of novelty or of inventive step.

Y: Document indicating lack of inventive step if combined with one or more other documents of the same category.

A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

E: Patent document published on or after, but with priority date earlier than, the filing date of the present application.

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